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TECHNICAL NOTE No: Inst. 960

ROYAL AIRCRAFT ESTABLISHMENT

Farnborough, Hants.

A 4-WAY ELECTRONIC SWITCH

MASTER FILE COPY

... JAMES

and

J. H. MITCHELL

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February, 1946.

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

A 4-way Electronic Switch

by

R.H. James
and
J.H. Mitchell

R.A.E. Ref. Inst.4108

SUMMARY

This note gives details of a 4 way electronic switch designed for use with strain gauge bridge networks.

4 signals fed into the switch are presented, amplified, at the output, 500 times per second each, in recurring succession.

A gain control for each channel is provided, maximum amplification in each case being 1000. The output may be applied to the Y plates of a CRT. It then appears as 4 spots, if there is no 'time base', with a vertical displacement between them which may be set as desired by 4 'Y shift' controls.

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1 Introduction

Although the problem of electronic switching for strain gauge work and kindred applications has been under investigation for some time, good switches are rare and very few electronic switches were available commercially in this country before the war.

It was therefore found necessary to design and build a four-way electronic switch to meet the following requirements:-

(i) A flat frequency response from zero to a few hundred cycles.

(ii) Sufficient amplification of a 100 mV. signal to give full CR tube deflection (this requiring about 100 volts) and

(iii) Cross modulation to be down to at least -40 dB's.

Probably the most difficult problem in the design of such a switch was the production of a suitably square pulse-shape for switching. As an overall gain of 1000 is required, any lack of squareness in the pulse is readily shown up. The usual difficulty of D.C. amplifiers was also encountered, and a very stable power pack is necessary for satisfactory operation.

2

2 Design Details

2.1 The Circuit Employed - (Refer to Diagram No. 10643). The system employs basically, two multi-vibrators, one locked to and running at half the speed of the other, to carry out the switching of six amplifying valves. The output of the faster multi-vibrator is applied to the supressor grids of four input amplifying valves A, B, C and D, the multi-vibrator signal on the valves A and C being 180 degrees out of phase with that to B and D.

The input signals are passed through gain controls and thence to the control grids of the valves, A, B, C and D. The anodes of valves A and B are commoned and also those of valves C and D. The commoned output from valves A and B is passed to the control grid of a fifth valve E and that from valves C and D is passed to control grid of a sixth valve F.

The output from the slower multi-vibrator is fed to the suppressors of valves E and F, whose anodes are commoned. In this anode circuit will appear the signals from A, B, C and D, in turn.

A certain amount of amplification is provided in the switch, the remainder being made up by a final amplifying stage, which also drops the mean D.C. level at its anode to earth potential, since its anode is connected through the load to a positive potential, and its cathode to a negative voltage with respect to earth.

Suppose now that the output is applied to the "Y" plates of a Cathode Ray Tube, to the "X" plates of which a sweep voltage is applied. Four lines will appear, each line corresponding to one of the switching circuits, and the bias settings will give a "Y" shift for each line, permitting movement in their relative positions, the gain settings controlling the amplitude of the signals appearing on these lines. It has been mentioned that the gain of each of the four channels to be switched is controlled at the input. The vertical position of the spot on the cathode ray tube for each of the four signal inputs is controlled by a bias, applied to each of the valves A, B, C and D.

The interaction i.e. the appearance of a signal on one trace, while actually being applied to another, must be reduced to a negligible quantity compared with the accuracy of measurement. This has been found to be better than 40 dB (100:1) in amplitude.

2.2 Difficulties Encountered in the Design - As indicated earlier, two major difficulties were encountered in design.

The first of these is the necessity to provide a very square switching voltage from the multi-vibrator. Not only must the top be flat, but the sides must be steep, and it was found that the normal multi-vibrator circuit did not give a sufficiently square output. The circuit has been modified by using pentodes with the screen grids as the multi-vibrator anodes, the output being taken from the anodes. This arrangement gives a marked improvement.

The second difficulty is that D.C. amplification must be employed. If condenser coupling were used, the effect of an applied D.C. signal to one channel would be that of changing the mean level of zero volts with respect to earth of the output. This would result in the shifting of all four traces, giving an apparent interaction of the signals. The primary difficulty in designing the D.C. amplifying circuits has been that of obtaining sufficient stability in the H.T. supply. Neon stabilisation has proved totally inadequate, and valve stabilisation using a battery reference voltage is now being employed. A new method of H.T.

3

stabilisation is also being evolved which it is hoped will be good to one part in 1000.

3 Application

When this switch is used with strain gauges and similar appliances, no time base is applied to the "X" plates, but the spot movements in the "Y" direction are photographed on a film moving in the "X" direction. A typical example of the trace obtained is shown in Plate 11 Fig.4.

For all applications so far, the highest frequency to be recorded is about a hundred cycles, and the existing speeds of the multi-vibrators of 1000 and 500 cycles/sec. are adequate, each of four signals being presented 500 times a second.

It may, however, be necessary substantially to increase the switching frequencies at a later stage, and preliminary experimental work has shown that this is possible and switching frequencies up to 90 kc are attainable. For non-recurring phenomena, the switching frequencies must be high in comparison with the frequencies in the phenomena under examination, while for recurrent phenomena, much higher frequencies than the switching frequencies can be displayed and a continuous "picture" is presented on the C.R. Tube when a 'time base' synchronised to the signal frequency is applied to the "X" plates. First reports on the use of this equipment in aircraft structural investigations are very encouraging.

4 Conclusion

A continuation of this development is the incorporation of the switch into a C.R. Tube assembly. This is now being undertaken, and will be reported on in due course.

Attached:

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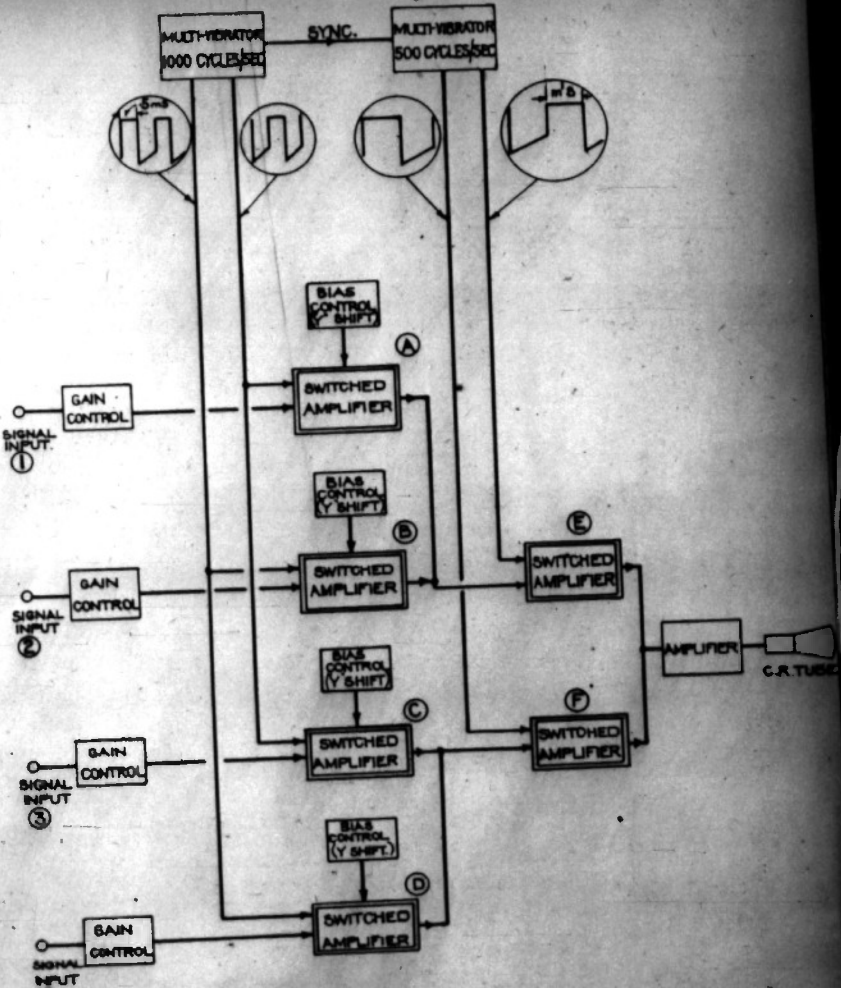

BLOCK SCHEMATIC.

4- WAY ELECTRONIC SWITCH.

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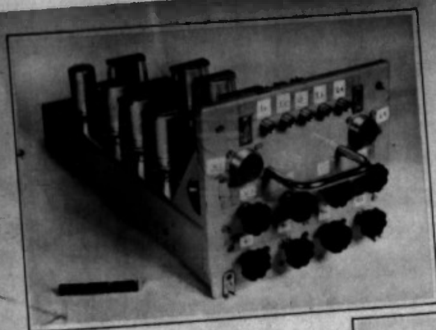
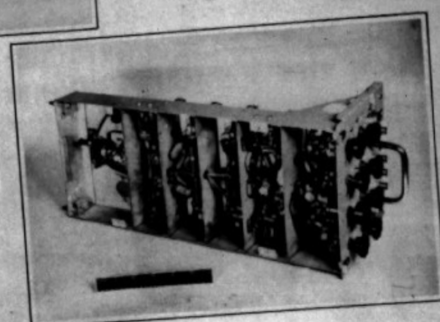
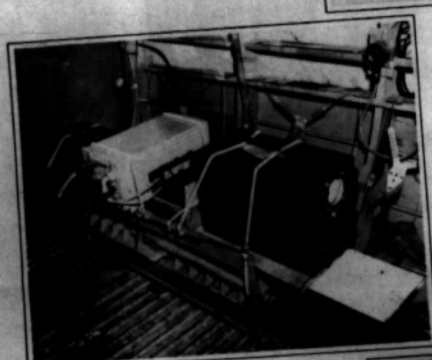
FIG. 13.



SWITCH (COVER REMOVED)



SWITCH (FROM BELOW)



GLIDER INSTALLATION FOR FOUR MEASUREMENTS

SPECIMEN OF RECORD

4-WAY ELECTRONIC SWITCH.

FIG. 13.

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TITLE: A 4-way Electronic Switch

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AUTHOR(S) : James, R. H.; Mitchell, J. H.
ORIG. AGENCY : Royal Aircraft Establishment, Farnborough, Hants
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Feb' 46	Restr.	Gt. Brit.	English	6	photos, diagrs

ABSTRACT:

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